



# REQUEST FOR ACTION (RFA) RESPONSE

## GLAST LAT Project Calorimeter Peer Review

17 – 18 March 2003

<b>Action Item:</b>	CAL – 022
<b>Presentation Section:</b>	Detector Elements
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**Request:** PIN-diode testing - LAT-DS-00209-10 specifies 10Krad ionizing radiation for lot testing/qualification of pin-diodes. The spec does not say whether under bias voltage or not, please clarify.

**Reason / Comment:** Increase in leakage current with neutron dose has been observed. But only folklore whether it must be done under bias or not.

**Response: 10 April 2003**

The irradiation of the PIN photodiodes during the GLAST mission will occur while biased at ~ 70V. The LAT total ionizing dose requirement for EEE parts is 4.5kRad(Si) under worst case bias (GLAST Mission System Specification, 433-SPEC-0001).

According to Jim Howard, NASA/GSFC Radiation Effects Branch, for simple structures such as PIN photodiode total dose testing without bias is acceptable.

All our radiation testing to date has been with unbiased diodes. The accelerated dose rate (10 – 1000 Rad/hour) of our testing would create large currents in the diodes.

The following note summarizes the on-orbit evaluation of the PIN photodiodes that were used on PICsIT experiment on ESA's INTEGRAL mission. It uses similar, but smaller (~ 1 cm<sup>2</sup>) Hamamatsu PIN photodiodes.

The INTEGRAL orbit is a highly eccentric orbit with perigee 9000 km, apogee 153 000 and inclination 56°. During the five first orbits, we have raised the perigee from 600 km to 9000 km. During these operations we have integrated 6 deep passages through the belts. Now with the nominal orbit, we escape the proton belts but we still pass through the electron belts.

The GLAST orbit is a low earth orbit, at an altitude of 550 km and a 28° of inclination.

### 1) High energy protons and neutrons

The Cosmic protons are the dominant source of charged particles background for the 90% of the GLAST orbit that is outside the SAA. The proton integrated flux at sunspot minimum is  $1.3 \cdot 10^{-1}$  p/s/cm<sup>2</sup>. This is approximately 40 times less than the INTEGRAL integrated flux (around 4 protons /s/cm<sup>2</sup>). (In a previous computation I found a factor above 300 but after revisiting the calculations I saw

that the CREME spectra computed by Eric were expressed in p/s/m<sup>2</sup>/Sr. Taking into account the solid angle there is a residual factor of 4 $\pi$ ).

Secondary neutrons can only be induced by high energy cosmic ray protons (energy above 500 MeV) interacting with the telescopes and the spacecraft via spallation nuclear reactions. For this kind of events, the INTEGRAL orbit is more unfavourable. At the first approximation 5 INTEGRAL months are equivalent to 200 GLAST months.

## 2) Low energy protons

The energetic solar particles are strongly attenuated by the geomagnetosphere and can be ignored.

For the SAA particles (low energy protons) the GLAST DPD are well shielded with the Al plates and the grid on one side and with the CsI crystals on the other side.

In conclusion, five months of INTEGRAL mission represent an accumulated dose greater than GLAST estimated lifetime.

After five months, concerning PICsIT, we do not observe any significant change in the energy resolution and gain of the <sup>22</sup>Na lines (511 keV and 1275 keV). The only changes are highly correlated with the temperature. This indicates that the transparency of the interface between the crystal and the DPD window should not be sensitive to the expected GLAST dose. Concerning the Dark current, it is more difficult to extract a value from the PICsIT data while the low energy threshold was tuned well above the background (~170 keV). All what we know is that if there is an increase, it is less than a factor 4.

The gain changes of ~1% for +/- 3°C around 7 or 8°C (mean value of PICsIT plane temperature). The resolution, uncorrected from the temperature fluctuations, is comprised between 16% and 17% at 511 keV. No change of the gain or the resolution has been detected due to another parameter than the temperature up to now.